

TITLE

**A SYSTEM FOR PROVIDING PROTECTION
FROM REACTIVE OXYGEN SPECIES**

CROSS-REFERENCE TO RELATED APPLICATIONS

This application refers to and relates to Disclosure Document No. 475763 filed in the U.S. Patent & Trademark Office on 19 June 2000, and the Commissioner is requested to place a true copy of that Disclosure Document in this file.

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates to compositions, methods and apparatus for reducing levels of reactive oxygen species in the body.

Description of the Related Art

It has been shown that animals on long-term well nourished, low calorie diets tend to live longer than those on other diets. They have a lower metabolism rate than control animals on normal diets, and with fewer chemical combinations taking place at the sites of energy production in the cells (the mitochondria), their blood sugar levels are lower and there are fewer combinations with proteins to produce plaque. Also, there are fewer byproducts of incomplete oxidation, including reactive oxygen species such as singlet oxygen atoms and hydroxyl radicals.

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body.

A further object of the invention is to provide a method of and apparatus for preventing the cellular damage caused by reactive oxygen species within an anatomical body.

These objects may be achieved in the practice of present invention, with a composition, method of delivery and apparatus for delivery of the composition to the human body, while providing protection from reactive oxygen species by intentionally artificially raising the concentration of a first fuel gas compound in the tissue of an animal to a level which is above the background level of the first fuel gas compound in the tissue.

The practice of this invention contemplates providing a person with a breathing gas composition including a fuel gas which may be hydrogen, or any gas that combines with oxygen, such as methane, ethane, propane or acetylene, or a combination of these. The composition may be provided at levels of fuel gas which are not explosive, to avoid explosion risk. Alternatively, compositions which are explosive may be provided with precautions taken to explosion-proof the environment around the person.

In one embodiment of the principles of the present invention, an apparatus is provided with a source of fuel gas is provided, along with a flow restrictor and valve, and a nasal cannula or mask for providing the gas to a person. The flow rate is set by the flow restrictor based on the minimum

1 respiration minute volume of the person to provide an exhaled breathing gas composition in which
2 the fuel gas is below the explosive limit.

3 In another embodiment, the invention provides an apparatus for providing a level of fuel gas
4 to an entire building. Here, the apparatus includes an explosion-proof blower for circulating air in
5 the building, ducting, a return inlet to the blower, and outlets in the rooms of the building. A
6 constant pressure source of a fuel gas is provided with a connection line to a flow-diffuser in the
7 ducting. A flow restrictor limits the flow rate of the fuel gas to a value which does not allow the
8 buildup of an explosive concentration of gas. A valve in the connection line is connected to the
9 blower and remains closed when the blower is off. A valve in the connection line is connected to a
10 flow sensor in the duct, and remains closed when there is no flow in the duct. Another valve is
11 connected to a fuel sensors inside the building. A vent is also provided in the attic of the building
12 to allow for escape of gases.

13 In another embodiment, a composition including one or more fuel gases with a density less
14 than that of air is provided as a breathing gas. An apparatus for providing this composition includes
15 a transparent container which is large enough for a person to be in, and which is open at the bottom
16 to retain the breathing gas composition by buoyancy and to permit entry and egress. The apparatus
17 also includes a flexible skirt around the lower portion, and in the container is an overflow pipe and
18 non-return flap valve. Additionally, an explosion-proof blower recirculates the gas inside the
19 container from an inlet muffler through a life-support system and returns the gas through a

1 muffler/diffuser pipe. The life-support system scrubs carbon dioxide, controls temperature and
2 humidity, adds oxygen, and may also scrub nitrogen, argon, oils and other contaminants. Alarms
3 and readouts for the status of the gas in the container may also be provided.

4 BRIEF DESCRIPTION OF THE DRAWINGS

5 A more complete appreciation of the invention, and many of the attendant advantages,
6 thereof, will be readily apparent as the same becomes better understood by reference to the following
7 detailed description when considered in conjunction with the accompanying drawings in which like
8 reference symbols indicate the same or similar components, wherein:

9 FIG. 1 is a schematic illustration of embodiments of the present invention which are an
10 apparatus and method for delivering a breathing gas composition to an individual;

11 FIG. 2 is a schematic illustration of embodiments of the present invention which are an
12 apparatus and method for delivering a breathing gas composition to a building; and

13 FIG. 3 is a schematic illustration of embodiments of the present invention which are an
14 apparatus and method for delivering a breathing gas composition to a confined region.

15 FIG. 4 is a schematic illustration of embodiments of the present invention which are an
16 apparatus and method for delivering a breathing gas composition to an individual using a helmet.

17 DETAILED DESCRIPTION OF THE INVENTION

18 The present invention is a method to produce a beneficial effect such as that seen with low-

1 calorie diets in animals, by neutralizing reactive oxygen species to reduce harm to the body. The
2 present method, as will be described in detail below, involves the maintenance of concentrations in
3 the body of one or more compounds whose purpose is to combine with and overwhelm the reactive
4 oxygen species, and to remove them as they are produced to greatly lower the levels of these reactive
5 oxygen species.

6 ^{Sub B1} These compounds are fuel gas compounds, to be detailed below. Fuel gases are commonly
7 burned with oxygen to produce heat. These are used as industrial gases, and general health and
8 safety guidelines for these gases have been established. These gases are all classified as simple
9 asphyxiants. [United States OSHA Regulations (Standards - 29 CFR, Gases, vapors, fumes, dusts,
10 and mists - 1926 55 Alp A), wherein is stated, "The limiting factor is the available oxygen which
11 shall be at least 19.5 percent and be within the requirements addressing explosion in part 1926."].
12 That is, the gases are not inherently toxic as long as adequate oxygen is supplied to the body, but
13 asphyxiation will result if the gas displaces oxygen. Since these are fuel gases and burn readily,
14 certain mixtures of the gases with oxygen will be explosive if ignited. This property of the gases will
15 be discussed further below.

16 The most studied of these gases for its effects on respiration is hydrogen. Deep-sea diving
17 trials have been conducted in which the participants were exposed to 20-40 atmospheres of hydrogen
18 gas for weeks at a time. This illustrates that substantial concentrations of hydrogen do not appear
19 to show any particular toxicity.

1 Methane and hydrogen are constituents of the atmosphere, and are also produced in the gut
2 during digestion of certain foods, so small quantities of these two gases exist naturally in the blood
3 stream. The wall thickness and low surface area of the gut compared to that of the lungs means that,
4 in the balance between the methods of supply and removal, only extremely low levels of these gases
5 can build up from digestive sources. Also, the low diffusivity of methane results in most of it leaving
6 the body as flatus. Hydrogen can better penetrate the gut, but again, blood levels are low as the
7 hydrogen is expelled almost immediately via the lungs. Only in completely closed environments such
8 as diving chambers or space vehicles or where there is some other method of continuous
replenishment to the lungs, can these gases achieve any substantial concentration in the body.

As a general rule, gas mixtures containing a fuel gas and oxygen are potentially explosive
at adequate levels of fuel and oxygen. For example, hydrogen in air is explosive at levels of about
4 to 75% by volume, methane at 5 to 15%, ethane at 3 to 12.5%, and acetylene at 2.5 to 80%. The
hydrogen deep diving trials mentioned above were performed below the explosive limit for oxygen,
and thus were performed in a non flammable atmosphere. To have a life-sustaining mixture and
avoid explosions at normal pressure, the breathing gas mixture must either be under the flammability
limit for the fuel gas, or else one must rigidly prohibit ignition sources.

9 The present invention provides methods and apparatus to achieve a certain level of a fuel gas
10 compound in solution in the body to destroy most of the reactive oxygen species while still in
11 aqueous solution, protecting the cells from the bulk of the damage they would otherwise do. In some

embodiments to be detailed below, the present invention achieves these levels at ambient pressure, unlike the conditions found, for example, in the hydrogen deep-sea trials discussed above. Even low levels of fuel gas compound in breathable gas, below the explosion limits, may raise the internal concentration of the compound well above background levels and offer useful protection.

For example, a level of hydrogen of about 1-2% in a breathing gas should yield an internal concentration that is several orders of magnitude higher than the background level occurring from natural diffusion from the gut. Higher percentages should provide higher protection, but may require using a breathing gas in the flammable range.

To achieve the desired levels of fuel gas compound in the body, one can supply the gas to the lungs for inspiration, either in an open circuit manner (for example, by a nose cannula), or in a controlled environment in homes, vehicles, places of work, public buildings, pressure vessels, space ships, full-body suits, self-contained breathing apparatus, tents (like oxygen tents), etc. Over time, the entire body equilibrates with the level of fuel gas being supplied.

Acetylene has a property which may make it particularly useful in this application. The solubility in water of acetylene at STP (standard temperature and pressure) is close to one liter/liter, a value which is 50 times higher than that of hydrogen and far higher than that of any of the other fuel gases. Water exposed to 80% acetylene at room temperature and sea level would absorb about 1 gram/liter into solution. As acetylene is several times more soluble in fat than in water, a 100 kg

man in these conditions would absorb perhaps 200 grams of acetylene.

Cellular energy production takes place at numerous sites scattered throughout the cell, the mitochondria. Typically, these have a volume of 1-10 cubic microns. As the cells are mostly water a 1 cubic micron volume would have the approximate numbers of molecules of fuel gas dissolved in it when in equilibrium with the mixtures at STP as shown in Table I.

<Table I>

<i>% Fuel Gas Inhaled</i>	<i># of Molecules in 1 Cubic Micron</i>	<i>Comment</i>
0.00005% H ₂ in air	1/4	Natural H ₂ level in air
3% H ₂ in air	16,200	Non-flammable w/ buffer
66.7% H ₂ , 33.3% O ₂	360,000	From electrolysis of water
1.6% C ₂ H ₂ in air	432,000	Non-flammable w/ buffer
5% C ₂ H ₂ in air	1,350,000	0.5 L/min C ₂ H ₂ in nasal cannula
70% H ₂ , 10% C ₂ H ₂ , 20% O ₂	3,080,000	Day? Easy enter& exit
80% C ₂ H ₂ , 20% O ₂	22,000,000	Night? May be narcotic
1000mg Vitamin C	<i>approx. 12,000</i>	<i>Peak level, for comparison</i>

1 The present invention will now be described in detail. With regard to the present invention,
2 the term "breathable composition" will refer to a gas mixture available to the lungs for inhalation.
3 Typically, a breathable gas mixture must have an adequate supply of oxygen to support life, and must
4 have a low enough level of toxic species so as not to be toxic.

5 Breathable compositions can, in general, be supplied in an open circuit, semi-closed circuit
6 or closed circuit manner. In an open circuit system, the breathable composition is supplied for
7 inhalation, and the exhaled gas leaves the system and is not included in the supplied breathable
composition. For example, supply of a gas via a nasal cannula would be an open-circuit system; the
exhaled gas leaves the vicinity of the body to the general atmosphere.

10 A closed circuit breathing apparatus involves continuous reuse of the same gas, with only
scrubbing or regeneration of the gas to maintain oxygen levels and remove respiration products or
toxins.

13 A semi-closed circuit is intermediate between the open circuit and closed circuit systems,
14 with some recirculation of exhaled gas and release of gas from the system to the general atmosphere.

15 In the embodiments to be described below, the term "fuel gas compound" is taken to mean
16 any chemical compound which in pure form is a gas and which in pure form can be readily oxidized
17 by oxygen for heat production. Possible fuel gas compounds in the present invention include

hydrogen, methane, ethane, propane and acetylene. Other compounds, such as the hydrocarbons ethene, n-butane, isobutane, 1-butene, etc., may also be used.

In a general embodiment of the invention, the invention involves intentionally artificially raising in a tissue of an animal--the term "animal" here being meant to include humans--a concentration of a fuel gas compound to a level which is above the background level in the tissue. The background level is here taken to mean the level of the fuel gas compound which would be present in the absence of the action taken to raise the level. As discussed above, for example, trace amounts of hydrogen or methane may be naturally found in tissues of animals; these trace levels would represent the background levels. Here, "intentionally artificially" is taken to mean that a particular action of a person is performed for the purpose of raising the concentration of the fuel gas compound.

In another general embodiment, the present invention involves providing an animal ("animal" again taken generically to include humans) with a breathing composition which contains oxygen intentionally supplemented with at least one fuel gas compound. The breathing gas composition may, accordingly, contain more than one fuel gas compound.

Here, the term "intentionally supplemented" means that the breathing composition is artificially prepared to contain greater than a background level in air of the fuel gas compound. For example, it is well known that people are exposed to levels of methane while working in coal mines,

1 dairy farms, oil wells, etc. However, ordinary work in such environments would not be viewed as
2 “intentionally supplemented” for the purposes of this invention, because there is no intention to raise
3 the level of methane above the background level of the air, which in this case may be substantial.
4 Moreover, the presence of methane in these environments would not be considered to be due to
5 artificial supplementation.

6 Likewise, a person may be exposed to methane or acetylene in air from, for example, a
7 natural gas leak or from use of welding equipment. Although the level of methane or acetylene is
8 artificially greater than the natural background level, such exposure would not be considered
9 “intentional supplementation” because there is no intent to raise the level of the compound in the air
10 breathed.

11 The present invention may be practiced in a number of more specific embodiments. In one
12 embodiment, the present invention involves providing an animal with a breathing composition which
13 contains oxygen intentionally supplemented with at least one fuel gas compound, with the breathing
14 composition provided at close to atmospheric pressure. This would be in contrast to alternative
15 embodiments in which the breathing gas composition was supplied in a hyperbaric or hypobaric
16 chamber.

17 In another embodiment of the method of the invention, the breathing composition as
18 described above is continually provided for a period of time greater than one hour. The period of

time of continuous providing may be four hours, greater than one day, greater than one week, or even greater than one month.

Typically, the time of continuous providing of the breathing composition will be less than 24 hours in the course of one day. For example, a typical day of use of the method of the present invention might be as follows:

8 hours in bed, supplied with the composition

1 hour for showering, making breakfast, etc., breathing regular air

4 hours in home office or living room, supplied with the composition

0.25 hour auto transit, supplied with the composition

1.5 hour meeting with client, breathing regular air

0.25 hour auto transit, supplied with the composition

3 hours in home office or living room, supplied with the composition

1.5 hours gardening or other outdoor activity, breathing regular air

0.5 hour, making dinner, breathing regular air

4 hours in home office or living room, supplied with the composition

In this schedule, the supply of the breathing composition in the car would be using a different apparatus than in the home, as will be described below. In this sample schedule, 19.5 hours of one day are spend breathing the breathing composition of the invention. Thus, in one embodiment, the present invention involves repeatedly breathing the breathable composition of the invention for a time period greater than 15 hours out of each day. Long-term use might be seen by averaging more

1 than 12 hours a day over a 30-day period.

2 In another embodiment of the method of the invention, the breathing gas composition is
3 provided in an open circuit system. The breathing gas composition may be provided by a nasal
4 cannula or a full-face or oral nasal mask.

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6 In another embodiment, the breathing gas composition may be provided in a chamber
7 enclosing at least a person's head.

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10 In one embodiment of the invention, the breathing gas composition may contain a fuel gas
11 compound or compounds such that the overall composition is explosive. That is, the concentrations
12 of fuel gas compounds and oxygen are such that the composition can undergo rapid, self-sustained
13 combustion if ignited. In this embodiment, the environment around the person will generally be
14 explosion-proofed to avoid igniting the inhaled or exhaled composition. Explosion-proofing
15 generally involves removal of sources of sparks or heat which can cause ignition.

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17 In one embodiment employing a chamber for providing the breathing gas composition, the
18 breathing gas composition is a lighter-than air composition and the chamber is opened at the bottom,
19 with the breathing gas composition being held in the chamber by buoyancy. Compositions
20 containing hydrogen may be used to achieve a light density. Such a composition may have a
21 buoyancy less than 75% that of air, or even less than approximately one-half that of air. One example

1 of a lighter-than-air composition contains approximately 75 to 80% hydrogen and approximately
2 20% oxygen.

3 In another embodiment, the breathing gas composition is prepared using a hydrogen/oxygen
4 mixture which is formed by the electrolysis of water.

5 Specific apparatus embodiments for providing breathing gas compositions will now be
6 described in detail. Turning now to the drawings, Fig.1 depicts a simple embodiment of an apparatus
7 of the invention for supplying a breathing gas composition containing a fuel gas compound to a
8 person. In Fig. 1, a person is illustrated using a nasal cannula. Constant pressure source 101 is a
9 source of one or more of the fuel gases, and the flow rate of the gas is controlled by flow
10 restrictor 102. An on-off valve 103 is used to turn the flow of gas on or off, and the gas is delivered
11 by nasal cannula 104. The person breathes ambient air along with the supplied fuel gas, therefore
12 creating the breathing gas composition during inhalation, achieving a desired fuel gas compound
13 concentration in the inspired breathing gas.

14 For example, using acetylene, a restrictor giving a flow of 0.2 L/min, coupled with a normal
15 resting Respiratory Minute Volume (RMV) of 10 L/min, would give an inspired concentration of
16 2% acetylene in air. A level of 2% is under the explosive limit for acetylene, and it is expected that
17 an explosive level of acetylene should not be achieved when acetylene is supplied in this way.

1 An alternative to nasal cannula 104 is an oral-nasal mask or a helmet in which the complete
2 breathing gas is supplied at rate sufficient to keep carbon dioxide levels at reasonably low levels. For
3 example, to maintain a carbon dioxide level of 1% of the concentration in the exhaled gas in a
4 helmet having good gas mixing, the effluent rate from the helmet must be 100 times the normal CO₂
5 production rate. Therefore, if CO₂ is produced at a typical rate of about 0.5 L/min, a flow-through
6 rate of approximately 50 L/min is required.

7 An embodiment employing a closed helmet with an open-circuit supply and exhaust system
8 is shown in Fig. 4. In Fig. 4, a pressurized electrolytic cell 402, in which water is electrolyzed,
9 delivers a hydrogen-oxygen mixture at low pressure to supply buffer tank 403. Thus, pressurized
10 electrolytic cell 402 and supply buffer tank 403, which are represented as shaded, are an embodiment
11 of a supply or source of a respirable gas mixture which includes a fuel gas. In this embodiment,
12 dome-loaded regulator 404 supplies the gas mixture via supply hose 405 to helmet 401. Regulator
13 404 is controlled by sensing line 406. Dome-loaded back-pressure regulator 407, via return hose 408,
14 controls the pressure in the helmet to be a negative pressure of approximately 1/4 to 1" of water, and
15 back-pressure regulator 407 is controlled by sensing line 409. Return buffer tank 410 smoothes the
16 flow and provides a more even inlet pressure to explosion-proof suction compressor 411.

17 The supply pressure of electrolytic cell 402 is low, typically a few PSI (pounds per square
18 inch). The supply hoses and regulators are large and the flows are relatively slow. Likewise, the
19 pressure change caused by suction compressor 411 is set on the order of 3 PSI, providing a

1 compression ratio of less than 1.4. This leads to a low heat of compression and avoids compression
2 being a source of ignition. The return system also uses large, slow-flow return components.

3 In operation, the system requires a slight negative pressure for the helmet to supply breathing
4 gas. Thus, the system starts automatically when the helmet is donned and stops when it is doffed.

5 Electrolytic cell 402 delivers 33.3% oxygen by volume from the electrolysis of water. By
6 constructing a semi-closed system, only enough production by the electrolytic cell is required to
maintain adequate oxygen supply. Thus the delivery from electrolytic cell 402 can be reduced by
about 85% relative to the open circuit system described above. Moreover, a higher partial pressure
of hydrogen can be delivered for respiration, with levels of 75 to 80% being possible. In addition
there would be lower power consumption and less effluent.

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12 Figure 2 shows an alternative supply apparatus of the invention which is designed to supply
the fuel gas to create a breathing gas composition for a house or other building. House 214 has the
13 following elements in the air-conditioning/heating system: explosion-proof blower 207, ducting 211,
14 return inlet to the blower 213, and outlets 209 into the various rooms. Constant-pressure source 201
15 of one or more of the fuel gases supplies the desired fuel gas or fuel gas mixture, and manual on-off
16 valve 202 allows a complete shut-off of the gas source. Turning on blower 207 opens normally-
17 closed valve 203. When the flow of air in duct 211 is detected by flow-sensor 208, valve 204 is
18 opened. Valve 204 remains closed when there is no flow in the duct. Several fuel-gas sensors 212

are illustrated; in this embodiment one is installed in each room. Each fuel-gas sensor 212 is linked to and controls one of valves 205. Valves 205 are designed to remain closed until signaled to open. Vent 215 is located in the attic to allow the escape of fuel gases lighter than air.

Here, blower 207 is explosion-proof, that is, designed to produce no sparks which might cause ignition, as a safety feature. However, in normal use the blower should not contact air which contains fuel gas at above the explosive limit.

When all of valves 203, 204, and 205 are open, fuel gas flow proceeds to flow restrictor 206, and on to flow-diffuser 210, downstream of blower 207 in ducting 211. Restrictor 206 is selected so that on a wind-free day a desired percentage of fuel gas compound in the air in house 214 is maintained when the fuel gas is flowing 75% of the time. This arrangement is a safety feature to avoid development of an explosive level of an explosive level of fuel gas. For example, for acetylene, using a desired maintenance level of 1.6 % in air, a failure of all other systems resulting in flow of gas 100% of the time will still not result in an explosive condition.

In normal use, fuel-gas sensors 212 also prevent the formation of an explosive level of gas by shutting down corresponding valve 205 if the gas level rises above a preset level. The apparatus of Fig. 1 therefore allows the continuous maintenance of a concentration of fuel gas in a house at a desired level below the explosive limit. Occupants of the house can thus be exposed to the fuel gas for substantial periods of time.

1 Fig.3 depicts an alternative embodiment of the invention, which is an apparatus for delivering
2 the fuel gas to a controlled space which is smaller than the entire building. In Fig. 3, inside office
3 301 is transparent container 302, which is open at the bottom for ingress and egress of a person.
4 Here, the transparent container is at least large enough to hold one person, and may occupy a
5 substantial portion of a room.

6 This embodiment employs the principle that mixtures of hydrogen, methane or acetylene with
7 oxygen are lighter than air, since the molecular weights of these fuel gases are less than the average
8 molecular weight of air, which is about 29 g/mol. This is particularly true at higher concentrations
9 of the fuel gas. The breathing gas used in this embodiment may be a potentially explosive mixture
10 of hydrogen, acetylene, and oxygen, with a density approximately than half that of air. This
11 composition of breathing gas can be taken to consist essentially of hydrogen, acetylene and oxygen.
12 Here, "consisting essentially of" is taken to mean that hydrogen, acetylene and oxygen are the
13 primary and active components, but small amounts of impurities not detracting from the essential
14 quality of the composition may be present. Thus, small amounts of nitrogen, which is essentially
15 inert, as well as carbon dioxide and other impurities which may accumulate in breathed gas, may be
16 present, as long as the gas retains its low density and reactive oxygen species-removing property.
17 Generally, oxygen levels will be kept at about 20% as in air. Being substantially lighter than air, this
18 gas mixture is held in place by in relative buoyancy and does not tend to drift down and out of
19 container 302.

1 In Fig. 3, reference numeral 303 indicates the division between the gas mixture and the air
2 below it, and a tethered and relatively impermeable balloon 304, filled with the mixture, floating on
3 the air layer, acts as a level indicator. Flexible skirt 318, prevents 'sloshing' of the mixture under the
4 lip of container 302 and into the room. An overflow pipe 310 with its entry several inches above the
5 bottom lip of container 302 and several inches below the level of the person's nose and mouth, leads
6 to non-return flap valve 316 located above any possible ignition sources, where low density will
7 cause any escaping mixture to vent harmlessly through attic vent 317 and into the atmosphere.

8 The various contents of office 301 near the container are all grounded or explosion-proof as
9 appropriate and any other heat sources which could trigger an explosion are eliminated. The
10 contents may include, for example, computer 305, monitor 306, explosion-proofed keyboard 307,
11 electrical outlets 308, and the lighting system 309.

12 To enter container 302, the person first kneels or lie on antistatic mat 315, which covers the
13 entire floor of office 301. Thus any existing static charge is dissipated before entering the bubble of
14 explosive gas.

15 The gas mixture inside container 302 is circulated and treated. Explosion-proof blower 312
16 takes the gas mixture from inlet muffler 311, located approximately at mouth level, feeds the gas
17 mixture through life support system 313, and then circulates the mixture back into container 302 via
18 muffler/diffuser pipe 314. Life support system 313 scrubs CO₂, controls temperature and humidity,

1 adds oxygen, and contains a secondary loop system for scrubbing nitrogen, argon, oils, and other
2 secondary contaminants. The life support system 313 also provides all appropriate alarms, readouts,
3 and redundancies for a system providing life support. For example, an alarm may indicate any level
4 of a toxin in the gas mixture, or any failure of the system.

5 Container 302 is of a size such that changes in vital life support parameters, in particular due
6 to respiration of the person, will generally be extremely slow. Thus, failure of any or all elements
7 of life support system 313 will not endanger the occupant of the container over the course of a single
day.

8 The system as shown in Fig. 3 is illustrated as a semi-closed system. A fully closed system,
9 such as a space-suit, bag or tent may also be used. Alternatively, it is possible to deliver a potentially
10 flammable gas mixture in an open-circuit system, in which the gas mixture would be constantly
supplied and vented away.

13 When using the embodiment of the invention shown in Fig. 3, it is essential that explosion
14 be prevented. Thus, this embodiment may only be used in a carefully controlled environment in
15 which all potential sources of ignition are eliminated.

16 The present invention therefore provides a method and apparatus for reducing reactive
17 oxygen species in humans by providing a breathing gas containing a level of a fuel gas. Although

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